

~~SPECIFICATION~~ *a1*METHOD AND ARRANGEMENT FOR REDUCING THE PUMP LIGHT AT  
THE EXIT OF A FIBER LASER *a2*

In a fiber laser, the resonator is composed of a specific fiber that contains a single mode fiber in the inside core this being matched in terms of dimensions and material to the wave length range of the laser to be achieved and the diameter thereof lying in the region of a few  $\mu\text{m}$ . This "laser fiber" is surrounded by a "pump fiber" having a diameter of a few hundred  $\mu\text{m}$  into which the pump light is coupled. The "laser fiber" is thus embedded into the core of the pump fiber. The pump fiber is surrounded by a ~~cladding~~ *sheath* of material having a different refractive index that guarantees the guidance of the pump light in the pump fiber, as known from light waveguide technology. The core of the pump fiber can have a round cross-section but can also have a cross-section deviating therefrom, for example rectangular or quadratic, in order to enable an especially good matching to the pump source (laser diode).

The pump mechanism occurs in that the pump light excites the laser fiber. As a result thereof, the pump energy is consumed more and more over the length of the fiber, namely, beginning at the pump source, the energy content of the pump fiber drops roughly exponentially up to the end, i.e. to the laser exit. Optical efficiencies of above 50% are achieved with fiber lasers. *for that purpose* To that end, fiber lengths of approximately 50 meters are required. Up to 90% of the pump light has been consumed by the end of the fiber. Due to the exponential consumption of the pump power, it is not meaningful for economical reasons to make the pump fiber even longer, i.e. approximately 10% of the pump light emerges from the pump fiber and is superimposed on the laser light from the inner core of the fiber; the laser light thereby emerges from the fiber as a thin, diffraction-limited bundle, whereas the pump light has a very large aperture angle.

The wave length of the pump source of a known fiber laser lies at 900 nm; the wave length of the *corresponding* ~~appertaining~~ laser lies at 1100 nm. The pump

power of this laser amounts to 20 W; the laser power amounts to approximately 10 W. Approximately 2 W pump power are superimposed on the laser light.

Given applications that attach importance to a precise laser power on the order of magnitude of 1%, as is generally required, for example, in reprographics, the presence of the pump light leads to considerable problems, since it does not follow the beam path of the laser light because of the different aperture. Substantial measuring errors in the sensors thus occur due to stray light that the pump light causes. Likewise, inadmissible heating by the pump light occurs in sensitive arrangements.

Although the pump light could be separated from the laser light by a steep edge filter, the filters are easily destroyed given high power densities. This leads to a spatially large structure and expensive filters. It would likewise be conceivable to intercept the pump light with suitable diaphragms. The problem with this is that either the diaphragms must be made so large that they also allow pump light to pass or there is the risk that the diaphragms burn given slight misadjustment.

An object of the invention is to find a simple method and a simple arrangement with which the remaining pump light is not even allowed to come to the end of the fiber but is already completely intercepted earlier, so that a reduction of the emerging pump light by at least the factor of 100 is achieved.

This object is achieved by the measures recited in claim 1. Advantageous developments of the invention are described in subclaims 2 through 8. The invention is described below with reference to the Figure.

The Figure shows a pump fiber that is shown in two cut sections for drafting-oriented reasons. The pump light is supplied via a focusing optics at one end of the fiber, the left end in the drawing. Let the fiber have a core diameter of approximately 70  $\mu\text{m}$ , and an inside diameter of approximately 300  $\mu\text{m}$  and an outside diameter of approximately 600  $\mu\text{m}$ . The pump light is guided by total reflection at the inside wall of the waveguide, this being illustrated with light rays provided with arrows. Inventively, the pump fiber is

stripped of its <sup>sheath 3</sup>cladding over the last section, i.e. in the right-hand part of the drawing (for example, over the last 50 cm). This can occur by etching off the coating. The <sup>sheath</sup>cladding is preferably etched off wedge-shaped, so that it tapers over, for example 40 cm beginning at the end facing toward the pump source and is then completely removed for a further 10 cm. As a result thereof, the remaining pump power of approximate 2 W is continuously eliminated into the environment over the distance of 40 cm. The pump fiber is usually surrounded by a protective sheath of tensile material, for example Kevlar fibers, that is in turn surrounded by a metal sheath. The heat transfer into the protective sheath can thus be controlled over the length of the wedge-shaped distance, so that no overheating occurs. How much <sup>of pump</sup> pump light still proceeds via the fiber core to the fiber exit can be checked over the length of the fiber completely freed from the protective <sup>cladding</sup>cladding. A length of 10 cm is completely adequate for most applications. In order to avoid reflections at the fiber end, the fiber end can also be additionally roughened. This can <sup>occur</sup> ~~enue~~ by grinding or by additional etching.



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